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AUGUST 1992

STATUS OF THE CALIFORNIA SEA LION (*Zalophus californianus californianus*) POPULATION IN 1992

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by

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ADMINISTRATIVE REPORT LJ-92-32

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STATUS OF THE CALIFORNIA SEA LION

(*Zalophus californianus californianus*)

POPULATION IN 1992

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NOTE: Coauthors agreed to provide unpublished counts for this report under the condition that these data not be cited. Please do not cite.

ABSTRACT

California sea lions are recovering from over exploitation that took place prior to passage of the U.S. Marine Mammal Protection Act of 1972. Three stocks were defined based on location of major rookeries: (1) U.S.; (2) Western Baja California; and (3) Gulf of California. We estimated population size from the estimated number of births by computing the predicted proportion of newborn pups in a population with a stable age structure, a hypothetical schedule of survivorship, and an annual factor of increase equal to the growth rate from annual counts of pups. In 1990 the U.S. stock had a population size of 111,016, and since 1983 it grew at 10.2% a year. The total population size of the Western Baja California stock is 74,467 and appears to be stable. The Gulf of California stock was estimated by Zavala (1990) to be 24,500-28,220 for 1987 from counts made at 34 rookeries and haulouts; the annual increase in counts of sea lions from 1979 to 1987 was about 1.98% per year. There is presently no quantitative method of estimating status (relative to MNPL or OSP) for the U.S. stock because: (1) there are no quantitative data to estimate carrying capacity from historical population levels; and (2) the lack of a density-dependent signal in recent counts of sea lion pups in the U.S. prevents us from infering population status from the current dynamics of the population. Status relative to OSP or MNPL for the two stocks in Mexico was not determined because little information is available for California sea lions in Mexico.

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INTRODUCTION

California sea lions (Zalophus californianus californianus) are found in temperate and subtropical waters off the western coast of North America from southern Canada to the southern coast of Mexico. They are commonly displayed in zoos and circuses because they adapt well to captivity and are easily trained. They are the most common pinniped in California and Mexico.

The Marine Mammal Protection Act of 1972 (MMPA) directs that populations be maintained at an optimal sustainable population (OSP) size with a range in size between environmental equilibrium (carrying capacity, or K) and a level from which maximum productivity would result (the maximum net productivity level [MNPL]). Previous assessments of the U.S. California sea lion population indicated it to be above its MNPL (DeMaster et al. 1982), or near MNPL, but not significantly above or below (Boveng 1988). The present assessment pertains to California sea lions in the U.S., but includes some information on animals in Mexico.

History of Exploitation and Management

Records of historic exploitation and distribution were compiled from the literature and personal communications by Helling (1984), Cass (1985), Seagars et al. (1985), Howorth (in press), and Stewart et al. (in press). Prior to European settlement, Gabrieleno, Nicoleño, and Chumash Indians preyed on California sea lions in the Channel Islands beginning at least 4,000-5,000 years ago (Stewart et al., in press). Extensive harvest of California sea lions for their oil and hides took place in the middle 1800's (Scammon 1874) resulting in a reduction of the population (Bonnot 1928a). In 1909 and 1927 sea lions were protected by California Law, but only in certain regions of the state (Bonnot 1928a). Until the Marine Mammal Protection Act (MMPA) became law in 1972, California sea lions were subject to various degrees of harvest for pet food, hides, trimmings, display (public and scientific), sport, and bounty; and also were killed to reduce fishery depredation and for target practice. There are few historical records to document the effects of these harvests on sea lion abundance. We assume the California sea lion population was substantially lower than historic levels when the MMPA was passed in 1972, but how much lower is unknown.

Life History

California sea lions breed in the United States at four islands off the southern California coast, and in Mexico at various islands along the western coast of Baja California and in the Gulf of California. The breeding season begins in May when adult males establish and defend territories and continues through July. Most births occur from mid-June to mid-July. Most births in California rookeries are in late June. The sex ratio at birth is 1:1 (Ono and Boness 1991). Females give birth to a

single pup and nurse it for approximately 8 days before going to sea for about 2 days. Lactating females alternate between feeding trips of 1.7 to 3.9 days and nursing periods ashore of 1.7 to 1.9 days (Antonelis et al. 1990, Heath et al. 1991). Pups are nursed on this cycle until they are weaned at 4 to 8 months of age (Reeves et al. in press); however, some pups are known to nurse for more than one year (Francis and Heath 1991b). Estrus occurs 3 to 4 weeks postpartum, and most females breed in the water or the water's edge with males that have successfully defended the territory (Reeves et al. in press).

California sea lion males grow to 2.4 m and 390 kg; females to 2.0 m and 110 kg. Newborn pups average 0.8 m and 6.0 to 7.7 kg (females) or 6.7 to 9.0 kg (males; Reeves et al. in press). During puberty males develop a sagittal crest on the forehead caused by a bony flange on the head. Females lack the sagittal crest. The ages at sexual maturity or first birth are not known. Immatures, adult females, and subadult males molt during August through October and adult males molt from November through February (Reeves et al. in press).

Adult males from rookeries at the Channel Islands in Southern California migrate north from August through September, winter as far north as Puget Sound and British Columbia, and then return south to the rookeries from March through May. An increase in abundance of males found ashore at rookeries in the Channel Islands in January and February (Stewart and Yochem 1984) is assumed to be due to an influx of animals from Baja California. The seasonal movements of adult females is unknown. Presumably they remain in the vicinity of the rookeries year-round, but some are known to migrate as far north as central California during El Niño conditions (Huber 1991). Some immature sea lions make northward migrations that are shorter in length than those of adult males (Huber 1991).

Other Background Information

Studies of foraging patterns of lactating female California sea lions at San Miguel Island indicate that they can dive to 241 m, but mean depth of dives per individual range from 31.1 m to 98.2 m (Feldkamp et al. 1991). During the summer lactating sea lions from San Miguel Island feed near Point Conception and south of San Miguel Island (Antonelis et al. 1990). They averaged 6.8 dive bouts per feeding trip during El Niño conditions and 10.7 the year before El Niño, with an average of 48.2 dives per dive bout before El Niño and 65.3 dives per dive bout during El Niño conditions (Feldkamp et al. 1991). No information is available on foraging patterns of other age and sex classes of California sea lions.

California sea lions consume a variety of prey (Everitt 1981, Antonelis et al. 1984, Ainley et al. 1982, Aurioles et al. 1984, Roffe and Mate 1984, Lowry et al. 1990, 1991), but diet

varies geographically. The prey found most often in the diet of California sea lions in Southern California are northern anchovy, market squid, jack mackerel, Pacific whiting, and rockfish (Antonelis et al. 1984; Lowry et al. 1990, 1991). Diet studies conducted at the rookeries located on San Clemente Island and San Nicolas Island from 1981 through 1986 (Lowry et al. 1990, 1991) noted the importance of anchovy to the diet of sea lions in southern California. Anchovy were eaten year round. These studies also documented significant seasonal and annual variability in the diet of sea lions which is probably associated with abundance and availability of their preferred prey.

Some of the sea lions' prey are of commercial and sport value. Commercial landings in 1989 of five prey species eaten by California sea lions in southern California (northern anchovy, Pacific mackerel, jack mackerel, market squid, and Pacific whiting) totaled 104,234 metric tons (Dickerson 1990).

California sea lions interact with commercial passenger fishing vessels (i.e., partyboats) and depredate sport fish caught by anglers (Miller et al. 1983; Hanan et al. 1989). A survey by Hanan et al. (1989) in 1984-1988 found that, on the average, at least one sea lion comes within 100 yards of a boat each fishing trip, one third of the sea lions were hooked or took a hooked fish per trip, and an average of one fish was taken per trip. Fewer interactions occurred during the breeding season (late spring and early summer). More interactions took place during the El Niño period (1984) than afterward (1985-88). The partyboat fishery caught 4.45 millon fish in 1989 (Dickerson 1990).

Other conflicts have arisen as result of an increase in the sea lion population. These conflicts, involving males that migrated into a region, include: (1) occupation of marinas in California at Monterey Bay and San Francisco Bay; and (2) the consumption, and subsequent exhaustion, of a stock of steelhead trout as the fish migrate through Hiram M. Chittenden Locks in Puget Sound, Washington (Gearin et al. 1988).

POPULATION AND STOCK STRUCTURE

Biological Basis of Populations

There are three subspecies of California sea lion, Zalophus californianus: Z. c. japonicus was found on the coasts of Japan and is probably extinct; Z. c. wollebaeki is found on the Galapagos Islands; and Z. c. californianus is found on the coast and on islands from British Columbia, Canada to southern Mexico. This report deals with the subspecies of California sea lion, Z. c. californianus, found in Mexico and the United States.

The breeding range of California sea lions extends from the Channel Islands off the coast of southern California, United States, to Isla Santa Margarita on the Pacific coast of Baja California, Mexico, and at various islands located in the Gulf of California (Mate 1977, Aurioles et al. 1983, LeBoeuf et al. 1983). Some births have occurred north of the Channel Islands (Braham 1974, Pierotti et al. 1977, Chambers 1979, Keith et al. 1984). The range during the non-breeding period (particularly for males) extends north to Vancouver Island, Canada and south to southern Mexico (Hancock 1970, Mate 1977, Bigg 1985, 1988, Gallo and Solorzano 1991).

The likelihood of genetic or demographic isolation of the U.S. breeding colonies of California sea lions that are located at Santa Barbara Island (SBI), San Clemente Island (SCI), San Miguel Island (SMI), and San Nicolas Island (SNI) is very small due to their relatively close proximity. Sea lions tagged as pups on these islands from 1981 through 1986 have shown inter-island movements, as well as northward movements into northern California (Oliver et al. 1988, Huber 1991, Oliver and Wexler 1991, Oliver 1991a, 1991b); however, to date no detailed analysis has been made. Some of the currently occupied breeding sites were presumably re-colonized from nearby islands (Scammon 1874, Bonnot 1928a, 1928b, 1931, Seagars et al. 1985).

At present there is little information on the movements of sea lions between the U.S. and Mexico. A few sea lions tagged as pups at San Miguel Island have been seen in western Baja California, Mexico (DeLong, unpubl. data). Movements from Baja California to the north have not been documented because of a lack of tagging studies in western Baja California, Mexico.

Recommended Stocks for Management Purposes

California sea lions have three major geographical breeding areas: (1) four islands in the U.S. located in the Southern California Bight; (2) six islands along the western coast of central Baja California, Mexico near Punta Eugenia, and Isla Santa Margarita on the western coast of southern Baja California; and (3) several islands located from the central to northern region of the Gulf of California, Mexico. Because the four U.S. breeding colonies are so close to each other and because no data are available to estimate rates of exchange between colonies, we assume that the entire U.S. population of California sea lions is a single stock as defined in the MMPA. The California sea lions breeding in Mexico may be part of the same stock, but the data available for those animals are limited. For this assessment, we divided the California sea lion population in Mexico into two stocks: (1) Western Baja California; and (2) Gulf of California.

POPULATION SIZE

Estimation Methods

The entire population of California sea lions cannot be counted because all age and sex classes cannot be found ashore simultaneously. An alternative method is therefore used to estimate population size from each year's production of pups. Counts of pups are used because each year's cohort (born May through July) is the only age class found ashore in nearly its entirety. Pup counts, made at peak abundance, are added to estimates of pre-census mortality to estimate births. We estimated population size from the estimates of births by computing the predicted proportion of newborn pups in a population with a stable age structure, a hypothetical schedule of survivorship, and an annual factor of increase equal to the growth rate from annual counts of pups. Because the age structure of California sea lions is unknown, we assumed that survivorship schedules for male and female sea lions are comparable to that of northern fur seals (Callorhinus ursinus; Smith and Polacheck 1981) and developed a life table for sea lions by scaling the relatively well-characterized survivorship schedule (Smith and Polacheck 1981) of female northern fur seal by hypothetical values of longevity for California sea lions using the method of Barlow and Boveng (1991).

In computing the stable age distribution, we used the observed rate of increase in pup counts as the annual factor of increase (see **POPULATION GROWTH RATES AND TRENDS**) derived for the stock. Longevity, defined here as the 99th percentile of the age distribution (Barlow and Boveng 1991), was assumed to be 22 years for females and 17 years for males (Boveng 1988). The stable age distribution with the assumed survivorship schedule are shown for three growth rates in Table 3. We assumed a sex ratio of 1:1 at birth.

To estimate population size the total number of pups produced is required, but because most counts of pups are made at the end of the pupping period the mortality that has occurred prior to the survey must be determined. This is referred to as pre-census mortality. Several studies (e.g. Brownell and LeBoeuf 1971; Bonnell et al. 1980; DeMaster et al. 1982; Stewart and Yochem 1986; Francis and Heath 1991a) have estimated pup mortality during portions, or all, of the breeding season. At San Miguel Island, between 1975 and 1981, dead pups that were counted during the census averaged 2.2 percent of the total of live and dead pups (DeMaster et al. 1982). During the same period, the count of dead pups plus known premature births averaged 5.8 percent of the total count of dead pups, premature births and live pups (DeMaster et al. 1982). Those values, based on single counts of dead pups at the times of the live pup counts, are known to under estimate mortality because carcasses decompose, are scavenged, wash away, and are buried (DeMaster et

al. 1982; Stewart and Yochem 1984, 1986; Francis and Heath 1991a).

Stewart and Yochem (1986) made daily counts of dead pups at a site on San Nicolas Island in 1984 and found that 10 percent of the pups born died before 7 July. Francis and Heath (1991a) used daily counts at two sites (and biweekly counts at the remaining sites) on San Nicolas Island to estimate that about 10 percent of all pups born died during the breeding season (approximately 17 May-26 July) in 1982 (a non-El Niño period) and 18 percent and 17 percent died in 1983 and 1984, respectively (an El Niño period). These estimates, based on daily counts of dead pups, reduce the error from carcass loss, but are limited to a few study sites because of the disturbance which would be caused by daily surveys of large rookeries.

The studies cited above indicate that pup mortality prior to the census (at peak live pup abundance) varies between sites and between years. It seems unlikely that mortality prior to the peak live pup count is less than about 5 percent of total births and it may be as great as 18 percent. We have assumed that 15 percent is probably typical, but we present a range of population size estimates based on 5, 10, 15, and 20 percent pre-census mortality.

Population Estimates

U.S. Stock

Counts of pups from Santa Barbara Island, San Clemente Island, San Nicolas Island, and San Miguel Island (Table 1) were totaled for 1990 to derive population estimates for the U.S. stock. In cases where multiple counts were available for an island, the highest count was used (as opposed to the mean count used for determining growth rate). The maximum total count of live pups at the four rookeries in 1990 was 26,704. We used 26,704 for deriving an estimate of the stock size. This value is slightly higher than the total-index count used for estimating population growth rates because it includes rookery areas at San Miguel Island that are not included in the SMI-index.

Using the U.S. count of 26,704 live pups and a pre-census mortality rate of 15%, we estimate there were 30,709 sea lions born in the U.S. stock in 1990. Using the methodology described above to estimate population size, with 30,709 births and a growth rate of 10.2 percent, we estimate the U.S. stock at 111,016 total individuals just after pupping in 1990 (Table 4).

To investigate the sensitivity of the population size estimate to the assumption about pre-census mortality we generated population estimates based on ranges of values for that parameter and for growth rates of 4.6 percent and 10.2 percent (Table 4), producing a range of estimates between 101,361 and 143,211 individuals. These estimates, however, have no

statistical confidence intervals. We believe that the population estimate (111,016) resulting from 15% pre-census mortality and an annual growth rate of 10.2 percent is the most probable.

Western Baja California stock

Counts of pups for rookeries on islands located off western Baja California, Mexico, (Table 2) were obtained from Vomend (1991), and DeAnda (unpubl. data). They were available for 1990 at rookeries located at Islas Los Coronados, Isla San Jeronimo, Isla Guadalupe, Islas San Benito, Isla Cedros, Isla Natividad, and Isla Santa Margarita. Because no count is available for the rookery at Isla Asuncion for 1990, we assumed that the 1989 count is comparable to the 1990 count. Approximately 11,411 pups were counted (or estimated) in 1990 for the Western Baja California stock.

Using the Western Baja California stock estimate of 11,411 live pups and a pre-census mortality rate of 15%, we estimate the number of live births in the Western Baja California stock to be 13,122. The Western Baja California stock with an annual factor of increase of 1.0 (see **POPULATION GROWTH RATES AND TRENDS**) and 13,122 births would number 74,467 individuals just after pupping in 1990 (Table 4).

To investigate the sensitivity of the population estimate to pre-census mortality we generated population estimates based on ranges of values for that parameter (Table 4). This yielded a population range between 67,986 and 77,702 individuals (as with the U.S. stock, these estimates have no statistical confidence intervals). We assumed that the population estimate (74,467) resulting from 15% pre-census mortality and a 1.0 annual factor of increase is the most appropriate.

Gulf of California stock

Counts of 3,422 pups and 2,277 pups for 1979 and 1981, respectively, were reported for rookeries in the Gulf of California by LeBoeuf et al. (1983). Zavala (1990) reported a count of 4,169 pups for rookeries in the Gulf of California, but this total came from counts made by him in 1986 and 1987, and by others in previous years for rookeries he did not count. Population estimates include counts of all animals seen plus correction factors for estimating pups and adult females missed during the census (Zavala 1990). The Gulf of California stock has been estimated at 22,620-24,520 for 1986 based on counts made at 30 rookeries/haulouts (Zavala et al. 1987); at 24,500-28,220 for 1987 based on counts made at 34 rookeries/haulouts (Zavala 1990); and at 17,646 for 1990 based on counts made at 11 rookeries/haulouts (Maravilla 1990).

Minimum population size

For the U.S. and Western Baja California stocks we propose to estimate the minimum population size by doubling the number of

pups counted because the entire population cannot be counted at one time and because counts of pups are all that is available. This number will account for the number of pups and adult females. We know that the population also contains an additional unknown number of males and juvenile females. Doubling the 1990 U.S. pup count of 26,704 we obtain a minimum population for the U.S. stock of 53,408 animals. For the Western Baja California stock the minimum population size for 1990 from 11,411 pups counted and estimated is 22,822 animals. The minimum population size for the Gulf of California stock is the actual number of animals counted in 1986 (when the most rookeries and haulouts were counted in the same year). For the Gulf of California stock the minimum population size is 18,701 animals (Zavala 1990).

POPULATION GROWTH RATES AND TRENDS

Population growth rates and trends

U.S. Stock

Counts of pups dating back to 1970 from the four major rookeries in the United States were compiled from various sources (Table 1). Where annual counts were missing for the years 1975-1990, we estimated them for each missing year by log-linear interpolation between adjacent counts: (1) 1980 at Santa Barbara Island; (2) 1978, 1979, and 1980 at San Clemente Island; and (3) 1978 and 1979 at San Nicolas Island (Table 1). For San Miguel Island we used an index (SMI-Index) of pups that were counted for nearly the entire rookery because some rookery areas were not counted each year.

To examine trends in stock growth (i.e. annual factor of increase) we summed the number of pups counted or interpolated, at Santa Barbara Island, San Clemente Island, San Nicolas Island, and San Miguel Island (using the SMI-Index) to get a total count of all pups produced each year from 1975 to 1990 (Figure 1). In cases where two or more counts were available for an island, the mean count was used. Using the natural logarithm of pups counted, versus year, the calculated average annual growth rate from 1975 to 1990 was 4.6 percent (Figure 2; slope = 0.045, s.e. = 0.007, $P < 0.001$, $F = 41.016$, $df = 14$, $R^2 = 0.746$).

From 1975 through 1990, El Niño Southern Oscillation (ENSO) events affected temperatures of California waters in 1976-77, 1983-84, and 1987-88, (Squire 1987, Cole and McLain 1989, Gary Sharp, pers. commun.[1]); a warming event in California occurred in 1989-90 (Gary Sharp, pers. commun.[1]). Examination of Figure 2

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[1]Gary Sharp, Scientific Director, Cooperative Institute for Research in the Intergraded Ocean Sciences, 2560 Garden Road, Monterey, CA 93940, pers. commun. July 1992.

indicates that pup counts for 1976 to 1982 and for 1983 to 1990 have different slopes, with each slope beginning at an El Niño period. We calculated the average annual growth rate for 1976 to 1982 as 9.1 percent (slope = 0.087, s.e. = 0.013, P = 0.001, F = 46.757, df = 5, R^2 = 0.903) and for 1983 to 1990 as 10.2 percent (slope = 0.098, s.e. = 0.005, P < 0.001, F= 453.260, df = 6, R^2 = 0.987).

The three annual rates of increase are indicators of short- and long-term growth rates. The 4.6% long-term growth rate indicates the rate of population growth which includes periodic environmental perturbations that affect the population. The 9.1% and 10.2% figures reflect short-term rates of increase in pup production following environmental perturbations. The 10.2% annual growth rate reflects the recent growth rate, following the 1983 El Niño.

Western Baja California stock

The 1979 pup counts for Islas San Benito, Isla Asuncion, and Isla Santa Margarita were compared to pup counts obtained in 1989 and 1990 for analysis of net growth rate for the Western Baja California stock (Table 2). The 1979 and 1989/90 counts were almost identical, suggesting no net growth during this period and estimate a zero annual growth rate for that stock.

Gulf of California stock

Counts of all animals made at five rookeries (San Jorge, Los Machos, San Esteban, San Pedro Martir, and San Pedro Nolasco) for 1979 to 1987 had an annual increase ranging from 1.04% to 2.95% with a mean of 1.98% (Zavala 1990).

Growth Rate at MNPL

The growth rate at MNPL of the U.S. stock and of the two stocks in Mexico are unknown because the status relative to OSP cannot be determined at this time. We do not know if the population is at or near MNPL.

STOCK STATUS RELATIVE TO OSP and K

Methods of OSP Determination

Previous assessments of California sea lions relative to OSP have been based on the dynamic response method (DeMaster et al. 1982, Boveng 1988) which uses density dependent changes in population growth rate (indexed by changes in counts of pups) to infer the qualitative status of the population relative to MNPL (Goodman 1988). Large environmental perturbations like El Niño events can, however, greatly influence the results of this analysis. Because the number of pup counts obtained since the El Niño of 1983 is insufficient for dynamic response analysis, the

present assessment must rely on other information and techniques to infer the status of the population relative to OSP.

One such technique is the randomization test for density dependence proposed by Pollard et al. (1987) which tests for evidence of density dependent compensation in the growth of the population. It is a non-parametric randomization test for density dependence applied to the counts of sea lion pups. The test statistic is the correlation between the first-difference of the log-transformed abundances and the log-transformed abundances themselves. The observed value of the test statistic is compared to the distribution of many such statistics obtained by random permutation of the observed first-differences. The test requires annual estimates of abundance and would be invalidated by inclusion of the 1982-1983 decline (which we interpret to be a density-independent decline). Also, any interpolation scheme to fill in missing counts would necessarily affect the result to the extent that the model for interpolation would typically be density-independent. Therefore, the only series of pup counts applicable to the test is the interval 1983-1990. The test indicated that there is no evidence of density dependence in this series of counts ($P = 0.50$).

The lack of a density-dependent signal in the recent counts of sea lion pups corroborates our finding that the data are not sufficient for dynamic response analysis. For that reason and because there are insufficient data to estimate the historic (pre-exploitation) sea lion abundance, there is presently no quantitative method of estimating status (relative to MNPL or OSP) of the U.S. stock. The limited abundance data available for rookeries in Mexico (Mate 1977, LeBoeuf et al. 1983, Zavala et al. 1987, Zavala 1990, Maravilla et al. 1991, DeAnda unpubl. data) are not sufficient to conduct reliable population assessments relative to MNPL or OSP for the two stocks of California sea lions in Mexico.

Condition Indices

Several population parameters may be useful measures of the condition of individuals. Pup weights, pup mortality, and attendance and diving behavior of lactating females showed changes during the 1983 El NIño perturbation. At San Miguel Island and San Clemente Island 4-month old pups were significantly lighter during the El Niño period in 1983 and 1984 than in other years (DeLong et al. 1991). An increase in the rate of pup mortality during El Niño was noted by Francis and Heath (1991a) at San Nicolas Island. Studies of attendance patterns (1982-1985) and of diving behavior (1982-1983) found that during El Niño periods, lactating females (1) increased their time at sea foraging, (2) spent more time diving, (3) had longer dive bouts, and (4) had more dives per bout (Heath et al. 1991, Feldkamp et al. 1991). These results indicate that a lactating female had difficulty foraging and maintaining a pup at

optimum condition during the 1983 El Niño event.

Regular monitoring of the diet, as an index of feeding strategy, may be an indicator of population condition. Diet studies of California sea lions by Antonelis et al. (1984) and Lowry et al. (1990, 1991) and Lowry (unpubl. data) identified prey species preferred by California sea lions in U.S. rookeries. The 1981-90 quarterly monitoring of the diet of sea lions at San Clemente Island indicates more non-preferred prey were consumed during the 1983-84 and 1988 California El Niño events (Figure 3; Lowry unpubl. data).

Determination of body fat, another important measure of body condition, can be used as an index to monitor environmental quality and its affect on individuals. Worthy (1991) found that lateral axillary blubber depth of adult California sea lions did not differ between 1990 and 1991, but for young-of-the-year animals it suggested that they had thinner blubber layer in 1991 compared to 1990. Using tritiated water to calculate body fat also showed that young-of-the-year had less fat in 1991 than 1990. Unfortunately, without additional information, the significance of inter-annual differences in this condition index are difficult to interpret.

CURRENT BIOLOGICAL REMOVALS

Incidental Take

Numbers of California sea lions killed incidentally by commercial fishing vessels operating in California (Table 5) were estimated from data collected by observers on fishing vessels, fishing log books, and fish landing receipts. Those estimates range from 1,865 sea lions killed in 1991 to 4,288 killed in the fishing year 1986/87 (Miller et al. 1983; Hanan et al. 1988, Hanan and Diamond 1989, Perkins et al. 1992a, 1992b). Except the estimates made for 1979 to 1981, the estimates of mortality included drift-gillnet and set-gillnet fisheries. The halibut and angel shark (set-gillnet) fisheries on islands off the southern California coast contributed from 31 percent (1983-84) to 59 percent (1985-86) of the estimated mortality (Hanan et al. 1988, Hanan and Diamond 1989).

Tag returns from Mexican fishermen indicate that tagged California sea lions are incidentally killed in Mexico (DeLong unpubl. data), but the level of this take has not been quantified.

The only estimates of incidental mortality of California sea lions to have been made for areas outside the state of California are for the Columbia River where about 30 animals are killed

during the winter (S. Jeffries pers. commun.[2]). It is assumed that some sea lions are taken in other areas of Oregon, Washington, and British Columbia, Canada; and that these would be predominantly males.

Entanglement

California sea lions have been observed entangled with monofilament line and gillnet, trawl net fragments, packing bands, rubber bands, polyfilament rope and line, and other man-made items (Stewart and Yochem 1987, Oliver 1991a, 1991b, T. Goff pers. commun.[3]). A quantitative study by Stewart and Yochem (1987) of sea lions hauled out at San Nicolas Island and San Miguel Island from 1983-86 found the following: (1) entangled animals were a very low proportion of those found ashore (entanglements ranged from 0.08% to 0.22%); (2) 52% of the entanglement material was monofilament gillnetting, 14% was monofilament line, and 25% was packing bands; and (3) yearlings and juveniles accounted for 72% of the entanglements. Similar entanglement rates (0.08% to 0.35%) were encountered at San Clemente Island for 1988-1991 where it was reported that yearlings and juveniles were affected the most (88% of observations) and that virtually all entanglements were by monofilament gillnet (Oliver 1991b). Marine mammal rehabilitation centers on the mainland treat sea lions entangled by gillnet material, but in smaller numbers compared to all other live strandings (Table 6); corroborating the inference that entangled animals make up a small proportion of the population.

Although only a small proportion of the population is affected by entanglement injuries, the incidental mortality resulting from these wounds has not been estimated. Sea lions entangled in monofilament gillnetting material most likely broke loose from a gillnet, and should probably be included as incidental take in fisheries, but there is no way of knowing if that happened. Floating debris cannot be implicated because monofilament sinks unless corks are attached; the animals observed with monofilament gillnetting material did not have corks or other floating devices attached to it. Animals that escape and subsequently die from entanglement are not observed by observers aboard fishing vessels, and therefore, are not part of the incidental mortality estimates. Commercial gillnet fishing is currently banned in northern California, Oregon and Washington (except for subsistence purposes by native Americans and in inland waters of Puget Sound, Gray's Harbor, Willapa Bay, the

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[2]Steven Jeffries, Washington Department of Wildlife, Marine Mammal Investigations, 7801 phillips Rd. SW, Tacoma WA 98498, pers. commun. April 1992.

[3]Tom Goff, Sea World, Animal Care Department, 1720 South Shores Rd, San Diego, CA 92109, pers. commun. July 1991.

Columbia River Mouth, and the Klamath River).

Illegal killing

There is also evidence of sea lion mortality resulting from gunshot wounds. Salmon troll fishermen shoot sea lions in northern California (Miller 1983), but no documentation exists for other parts of the state or for other fisheries. Lowry and Folk (1987) reported that 11% of 121 fresh or moderately decomposed dead strandings examined between October 1980 and September 1983 in San Diego County, California, and 82% of 11 dead strandings at Santa Catalina Island had gunshot wounds. While it is possible that these animals could have been shot after they were dead and floating on the surface, it may be assumed that they were shot by fishermen when the animals endangered their catch or gear. Small numbers of live strandings of sea lions with gunshot wounds recovered in San Diego County (Table 6; [Tom Goff, pers. commun.[4]]) indicate that live animals are being shot. The magnitude of this mortality is unknown.

Other causes

Pollutants

Premature births were first noted in California sea lions in 1968, but an analysis of the annual incidence rate was not documented until the early 1970's (DeLong et al. 1973, Gilmartin et al. 1976). The rates of premature births reached 20% of pups born in 1972 (Gilmartin et al. 1976), but rates have subsequently decreased and are currently approximately 2% (DeLong unpubl. data). Studies suggested an interrelationship between the level of environmental contaminants, disease agents and rates of premature parturition (DeLong et al. 1973, Gilmartin et al. 1976).

In 1970 premature and full term pups and mothers were collected and their tissue analyzed for organochlorine pollutant residues (DeLong et al. 1973). Premature pups and their mothers were found to have concentrations of organochlorine pollutant residues 2 to 8 times higher in their tissues than did females and pups born at term. Premature parturient females were also younger (averaging 8 years) than full term parturient females (averaging 12 years).

The 1970 study was replicated in 1972 with collection of 10 females and their premature pups and 10 females and their full term pups (Gilmartin et al. 1976). The associative relationship between high organochlorine residues and premature parturition again held, with levels being 4 to 8 times higher in tissues of premature parturient females than in females which gave birth to full term pups. In addition, in females which had given birth

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[4]Tom Goff, Sea World, Animal Care Department, 1720 South Shores Rd, San Diego, CA 92109, pers. commun. July 1991.

to premature pups, they found antibody titers of Leptospira pomona in four animals, interstitial nephritis in kidneys of two additional animals, and obtained a Leptospira isolate from the kidney of one of the four animals which had significant titers to Leptospira. None of the females which had given birth to full term pups had significant Leptospira titers but one animal had interstitial nephritis in its kidney. The lack of significant serum titers to Leptospira among 6 of 10 premature parturient females observed by Gilmartin et al, (1976) does not necessarily mean Leptospira were not present.

Live captures

Rehabilitation centers throughout California care for sick and injured California sea lions. Almost all of the animals that are rehabilitated are released to the wild, but a few remain in captivity (Howorth, in press). The number of sea lions removed in this manner is not known, but they are few in number because there is currently a surplus of these animals in captivity due to most zoos and oceanaria having their own captive breeding programs.

Other removals

Since 1990, three California sea lions were either intentionally or unintentionally killed during research activities (I. Lagomarsino, pers. commun.[5])

ACKNOWLEDGEMENTS

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[5]Irma Lagomarsino, Fishery Biologist, National Marine Fisheries Service, Southwest Region, Suite 4200, 501 West Ocean Blvd., Long Beach, CA 90802-4213, pers. commun. May 1992.

27-30 April 1992 at SWFSC, La Jolla, CA.

LITERATURE CITED

Ainley, D. G., H. R. Huber, and K. M. Bailey. 1982. Population fluctuations of California sea lions and the Pacific whiting fishery off central California. Fishery Bulletin, U. S. 80:253-258.

Antonelis Jr., G. A., C. H. Fiscus, and R. L. DeLong. 1984. Spring and summer prey of California sea lions, Zalophus californianus, at San Miguel Island, California, 1978-79. Fishery Bulletin, U. S. 82(1):67-76.

Antonelis, G. A., B. S. Stewart, and W. F. Perryman. 1990. Foraging characteristics of female northern fur seals (Callorhinus ursinus) and California sea lions (Zalophus californianus). Can. J. Zool. 68:150-158.

Aurioles, D., F. Sinsel, C. Fox, E. Alvarado, and O. Maravilla. 1983. Winter migration of subadult male California sea lions (Zalophus californianus) in the southern part of Baja California. J. Mammal. 64:513-518.

Aurioles, D., C. Fox, F. Sinsel, G. Tanos. 1984. Prey of the California sea lion (Zalophus californianus) in the Bay of La Paz, Baja California Sur, Mexico. J. Mamm. 65:519-521.

Aurioles, D. and B. J. LeBoeuf. 1991. Effects of the El Niño 1982-83 on California sea lions in Mexico. In F. Trillmich and K. A. Ono (editors), Pinnipeds and El Niño: Responses to environmental stress. p. 112-118. Springer-Verlag, Berlin Heidelberg New York.

Barlow, J. and P. Boveng. 1991. Modeling age-specific mortality for marine mammal populations. Marine Mammal Science 7:50-65.

Bigg, M. A. 1985. Status of the Steller sea lion (Eumetopias jubatus) and California sea lion (Zalophus californianus) in British Columbia. Can. Spec. Publ. Fish. Aquat. Sci. 77. 20 pp.

Bigg, M. A. 1988. Status of the California sea lion, Zalophus californianus, in Canada. Canadian Field Naturalist 102:307-314.

Bonnell, M. L., B. J. Le Boeuf, M. O. Pierson, D. H. Dettman, G. D. Farrens, C. B. Heath, R. F. Gantt, and D. J. Larsen. 1980. Pinnipeds of the Southern California Bight. In Marine mammal and seabird surveys of the Southern California Bight area 1975-1978. Vol. 3, Investigators's Reports, Part 1. 535 pp. NTIS PB81-248-71.

Bonnot, P. 1928a. Report on the seals and sea lions of California. California Department of Fish and Game, Fish Bulletin no. 14.

Bonnot, P. 1928b. The sea lions of California. California Fish and Game 14:1-16.

Bonnot, P. 1931. The California sea lion census for 1930. California Fish and Game 17:150-155.

Boveng, P. 1988. Status of the California sea lion population on the U. S. west coast. Administrative Report LJ-88-07, Southwest Fisheries Center, La Jolla, California. 26pp.

Braham, H. W. 1974. The California sea lion on islands off the coast of San Luis Obispo County, California. California Fish and Game 60:79-83.

Brownell, R. L. Jr., and B. J. Le Boeuf. 1971. California sea lion mortality: natural or artifact? In D. Straughan (ed.), Biological and oceanographical survey of the Santa Barbara Channel oil spill, 1969-1970. Univ. South. Calif., Allan Hancock Foundation. Vol. 1, Chapter 14., pp 287-300.

Cass, V. L. 1985. Exploitation of California sea lions, Zalophus californianus, prior to 1972. Marine Fisheries Review 47:36-38.

Chambers, J. R. 1979. Population studies of California sea lions near Diablo Canyon, California. M. S. Thesis, California Polytechnic State University, San Luis Obispo. 54 pp.

Cole, D. A. and D. R. McLain. 1989. Interannual variability of temperature in the upper layer of the North Pacific eastern boundary region, 1971-1987. NOAA Technical Memorandum NMFS NOAA-TM-NMFS-SWFC-125. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 14 pp.

DeLong, R. L., W. G. Gilmartin and J. G. Simpson. 1973. Premature births in California sea lions: Association with high organochlorine pollutant residue levels. Science 181:1168-1170.

DeLong, R. L., G. A. Antonelis, C. W. Oliver, B. S. Stewart, M. S. Lowry, and P. K. Yochem. 1991. Effects of the 1982-1983 El Niño on several population parameters and diet of California sea lions on the California Channel Islands. In F. Trillmich and K. A. Ono (editors), Pinnipeds and El Niño: Responses to environmental stress. p. 166-172. Springer-Verlag, Berlin Heidelberg New York.

DeMaster, D. P., D. J. Miller, D. Goodman, R. L. DeLong and B. S. Stewart. 1982. Assessment of California sea lion fishery interactions. In Transactions of the 47th North American Wildlife and Natural Resources Conference, 1982. Wildlife Management Institute, Washington, D.C.

Dickerson, T. 1990. Review of some California fisheries for 1989. CalCOFI Rep. 31:9-21.

Everitt, R. D., P. J. Gearin, J. S. Skidmore, and R. L. DeLong. 1981. Prey items of harbor seals and California sea lions in Puget Sound, Washington. Murrelet 62:83-86.

Feldkamp, S. D., R. L. DeLong, and G. A. Antonelis. 1991. Effects of El Niño 1983 on the foraging patterns of California sea lions (Zalophus californianus) near San Miguel Island, California. In F. Trillmich and K. A. Ono (editors), Pinnipeds and El Niño: Responses to environmental stress. p. 146-155. Springer-Verlag, Berlin Heidelberg New York.

Francis, J. M. and C. B. Heath. 1991a. Population abundance, pup mortality, and copulation frequency in the California sea lion in relation to the 1983 El Niño on San Nicolas Island. In F. Trillmich and K. A. Ono (editors), Pinnipeds and El Niño: Responses to environmental stress. p. 119-128. Springer-Verlag, Berlin Heidelberg New York.

Francis, J. M. and C. B. Heath. 1991b. The effects of El Niño on the frequency and sex ratio of suckling yearlings in the California sea lion. In F. Trillmich and K. A. Ono (editors), Pinnipeds and El Niño: Responses to environmental stress. p. 193-204. Springer-Verlag, Berlin Heidelberg New York.

Gallo, J. P. and J. L. Solorzano. 1991. Two new sightings of California sea lions on the southern coast of Mexico. Marine Mammal Science 7:96.

Gearin, P. J., R. Pfeifer, S. J. Jeffries, R. L. DeLong, and M. A. Johnson. 1988. Results of the 1986-1987 California sea lion-Steelhead trout predation control program at the Hiram M. Chittenden Locks. Northwest and Alaska Fisheries Center Processed Report 88-30. Seattle, Washington. pp. 111.

Gilmartin, W. G., R. L. DeLong, A. W. Smith, J. C. Sweeney, B. W. De Lappe, R. W. Risenbrough, L. W. Griner, M. D. Daley, and D. B. Peakall. 1976. Premature parturition in the California sea lion. J. Wildl. Diseases 12:104-115.

Goodman, D. 1988. Dynamic response analysis. I. Qualitative estimation of stock status relative to maximum net productivity level from observed dynamics. Marine Mammal Science 4:183-195.

Hancock, D. 1970. California sea lion as a regular winter visitant off the British Columbia coast. J. Mammal. 51:614.

Hanan, D. A., S. L. Diamond, and J. P. Scholl. 1988. Estimates of sea lion and harbor seal mortalities in California set net fisheries for 1983, 1984, and 1985. Final Rept. NA-86-ABH-00018 submitted October 1988 to NOAA, National Marine Fisheries Service, Southwest Region, 300 South Ferry St., Terminal Island, CA. 10 pp.

Hanan, D. A. and S. L. Diamond. 1989. Estimates of sea lion, harbor seal, and harbor porpoise mortalities in California set net fisheries for 1986-87 fishing year. Final Rept. NA-86-ABH-00018 submitted January 1989 to NOAA, National Marine Fisheries Service, Southwest Region, 300 South Ferry St., Terminal Island, CA. 10 pp.

Hanan, D. A., L. M. Jones, and R. B. Read. 1989. California sea lion interaction and depredation rates with the commercial passenger fishing vessel fleet near San Diego. CalCOFI Rep. 30:122-126.

Heath, C. B. and J. M. Francis. 1983. Population dynamics and feeding ecology of the California sea lion with applications for management: Results of 1981-1982 research on Santa Barbara and San Nicolas Islands. Administrative Report LJ-83-04C. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 48 pp.

Heath, C. B., K. A. Ono, D. J. Boness, and J. M. Francis. 1991. The influence of El Niño on female attendance patterns in the California sea lion. In F. Trillmich and K. A. Ono (editors), Pinnipeds and El Niño: Responses to environmental stress. p. 138-145. Springer-Verlag, Berlin Heidelberg New York.

Helling, H. E. 1984. A follow-up report on available data for California and Steller sea lion (Zalophus californianus, Eumetopias jubata) exploitation prior to 1950. Administrative Report LJ-84-45C. National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California. 10 pp.

Howorth, P. C. In press. Commercial collection of pinnipeds in the California Channel Islands, 1877-1981. In: F. G. Hochberg (editor), Third California Islands Symposium: Recent advances in research on the California Islands. Santa Barbara Museum of Natural History: Santa Barbara, California.

Huber, H. R. 1991. Changes in the distribution of California sea lions north of the breeding rookeries during the 1982-83 El Niño. In F. Trillmich and K. A. Ono (editors), Pinnipeds and El Niño: Responses to environmental stress. p. 129-137. Springer-Verlag, Berlin Heidelberg New York.

Keith, E. O., R. S. Condit, and B. J. LeBoeuf. 1984. California sea lions breeding at Año Nuevo Island, California. Journal of Mammalogy 65(4):695.

LeBoeuf, B. J., D. Aurioles, R. Condit, C. Fox, R. Gisiner, R. Romero, and F. Sinsel. 1983. Size and distribution of the California sea lion population in Mexico. Proceedings of the California Academy of Sciences 43(7):77-85.

Lowry, M. S., L. J. Hansen, and S. D. Hawes. 1987. California sea lion and northern elephant seal pup counts and tagging at Santa Barbara Island, California, from 1983 through July 1986. Administrative Report LJ-87-03. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 19 pp.

Lowry, M. S. and R. L. Folk. 1987. Feeding habits of California sea lions from stranded carcasses collected at San Diego County and Santa Catalina Island, California. Administrative Report LJ-87-15. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 33 pp.

Lowry, M. S., C. W. Oliver, C. Macky, and J. B. Wexler. 1990. Food habits of California sea lions Zalophus californianus at San Clemente Island, California, 1981-86. Fishery Bulletin, U.S. 88:509-521.

Lowry, M. S., B. S. Stewart, C. B. Heath, P. K. Yochem, and J. M. Francis. 1991. Seasonal and annual variability in the diet of California sea lions Zalophus californianus at San Nicolas Island, California, 1981-86. Fishery Bulletin, U.S. 89:331-336.

Lowry, M. S. and W. L. Perryman. 1992. Aerial photographic census of California sea lion (Zalophus californianus) pups at San Miguel Island for 1987-1990 and San Nicolas Island, California for 1990. Administrative Report LJ-92-19. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 20 pp.

Maravilla, M. O., L. Fleischer, P. Loreto. 1991. Actividades del proyecto lobo marino del Golfo de California 1990. Abstract. XVI Reunion Internacional sobre el estudio de los Mamiferos Marinos en Mexico. April 1991.

Mate, B. R. 1977. Aerial censusing of pinnipeds in the eastern Pacific for assessment of population numbers, migratory distributions, rookery stability, breeding effort, and recruitment. U. S. Marine Mammal Commission Report No. MMC-75/01. NTIS PB-265-859.

Miller, D. J., M. J. Herder, and J. P. Scholl. 1983. California

marine mammal-fishery interaction study, 1979-1981. Administrative Report LJ-83-13C. National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California. 233 pp.

Odell, D. K. 1975. Breeding biology of the California sea lion, Zalophus californianus. Rapp. P.-v. Reun. Cons. int. Explor. Mer, 169:374-378.

Oliver, C. W. and M. S. Lowry. 1987. Pinniped studies conducted between August, 1981 and December, 1982 at San Clemente Island, California. Administrative Report LJ-87-23. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 47 pp.

Oliver, C. W., M. S. Lowry, and L. M. Ferm. 1988. Pinniped studies conducted at San Clemente Island, California during 1983. Administrative Report LJ-88-08. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 46 pp.

Oliver, C. W. and J. Wexler. 1991. 1985 field studies on pinnipeds at San Clemente Island. Administrative Report LJ-91-24. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 31 pp.

Oliver, C. W. 1991a. 1986-1987 field studies on pinnipeds at San Clemente Island. Administrative Report LJ-91-25. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 29 pp.

Oliver, C. W. 1991b. 1988-1991 field studies on pinnipeds at San Clemente Island. Administrative Report LJ-91-27. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 33 pp.

Ono, K. A., and D. J. Boness. 1991. The influence of El Niño on mother-pup behavior, pup ontogeny, and sex ratios in the California sea lion. In F. Trillmich and K. A. Ono (editors), Pinnipeds and El Niño: Responses to environmental stress. p. 185-192. Springer-Verlag, Berlin Heidelberg New York.

Perkins, P., J. Barlow, and M. Beeson. 1992a. Report on pinniped and cetacean mortality in California gillnet fisheries: 1988-1990. Administrative Report LJ-92-14. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 32 pp.

Perkins, P., J. Barlow, and M. Beeson. 1992b. Report on pinniped and cetacean mortality in California gillnet fisheries: 1991. IWC Working paper SC/44/SM14.

Pierotti, R. J., D. G. Ainley, T. J. Lewis, and M. C. Coulter. 1977. Birth of a California sea lion on Southeast Farallon Island. California Fish and Game 63(1):64-66.

Pollard, E., K. H. Lakhani, and P. Rothery. 1987. The detection of density-dependence from a series of annual censuses. Ecology 68:2046-2055.

Reeves, R. L., B. S. Stewart, and S. Leatherwood. In press. The Sierra Club handbook of seals and sirenians. Sierra Club Books, San Francisco. 320 pp.

Roffe, T. J. and B. R. Mate. 1984. Abundances and feeding habits of pinnipeds in the Rogue River, Oregon. J. Wildl. Manage. 48:1262-1274.

Scammon, C. M. 1874. The marine mammals of the north-western coast of North America. Dover Publications, Inc., New York. 319 pp.

Seagars, D. J., D. P. DeMaster and R. L. DeLong. 1985. A survey of historic rookery sites for California and northern sea lions in the Southern California Bight. Administrative Report LJ-85-13, National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California.

Smith, T. D. and T. Polacheck. 1981. Reexamination of the life table for northern fur seals with implications about population regulatory mechanisms. In C. W. Fowler and T. D. Smith (eds.), Dynamics of large mammal populations. p. 99-120. John Wiley and Sons.

Squire, J. L. 1987. Relation of sea surface temperature changes during El Niño to the geographical distribution of some important recreational pelagic species and their temperature parameters. Marine Fisheries Review 49(2):44-57.

Stewart, B. S. and P. K. Yochem. 1984. Seasonal abundance of pinnipeds at San Nicolas Island, California, 1980-1982. Bulletin Southern California Academy of Sciences 83:121-132.

Stewart, B. S. 1985. Population biology of pinnipeds at San Miguel Island, 10 June through 29 August 1985. HSWRI Technical Report 85-185. Hubbs-Sea World Research Institute, 1700 South Shores Rd., San Diego, CA 92109.

Stewart, B. S. and P. K. Yochem. 1986. Assessment of the population dynamics of the California sea lion (Zalophus californianus) at San Nicolas Island, 1984-1985. Administrative Report LJ-86-11C. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California.

Stewart, B. S. and P. K. Yochem. 1987. Entanglement of pinnipeds in synthetic debris and fishing net and line fragments at San Nicolas and San Miguel Islands, California, 1978-1986. Marine Pollution Bulletin 18:336-339.

Stewart, B. S., P. K. Yochem, R. L. DeLong, and G. A. Antonelis. (In press). Trends in abundance and status of pinnipeds on the Southern California Channel Islands. In: F. G. Hochberg (editor), Third California Islands Symposium: Recent advances in research on the California Islands. Santa Barbara Museum of Natural History: Santa Barbara, California.

Vomend, I. 1991. Report of a census of California sea lions, Zalophus californianus, on Guadalupe Island and adjacent islets. Administrative Report LJ-91-17C, National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California, 92038.

Wexler, J. and C. W. Oliver. 1988. Pinniped research conducted at San Clemente Island during 1984. Administrative Report LJ-88-16. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 53 pp.

Worthy, G. A. J. 1991. Validation of biolectrical impedance analysis for assessing body composition of California sea lions: A report to NMFS. Administrative Report LJ-91-44C. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California. 22 pp.

Zavala G., A., A. Aguayo L., and B. Morales V. 1987. Las loberas de Zalophus californianus en el Mar de Cortez, Mexico. Presented at XII Reunion Internacional para el estudio de los Mamiferos Marinos, April 1987, Universidad Autonoma de Baja California Sur, La Paz, B.C.S. 18pp.

Zavala G., A. 1990. La poblacion del lobo marino comun, Zalophus californianus (Lesson 1828) en las islas del Golfo de California, Mexico. Thesis, Facultad de Ciencias, UNAM. 253 pp.

Table 1. California sea lion pups counted at Santa Barbara Island (SBI), San Clemente Island (SCI), San Nicolas Island (SNI), and San Miguel Island (SMI), California, United States.

Year	SBI	SCI	SNI	SMI	SMI_{INDEX}
1970			2,271[1]		
1971			3,500[1]	4,285[2]	4,285[2]
1972				3,501[2]	3,501[2]
1975	684[3]	608[3]	3,800[3]	6,947[2]	6,811[2]
1976	582[3]	413[3]	2,887[3]	8,011[2]	7,711[2]
1977	493[3]	351[3]	3,773[3]	6,972[2]	6,792[2]
1978	4654	[411]	[4,427]	7,429[2]	6,896[2]
1979	625[4]	[483]	[5,195]	8,146[2]	7,831[2]
1980	[675]	[567]	6,096[14] 6,304[16]	6,951[2]	6,388[2]
1981	730[4]	666[8]	6,704[14] 5,693[18] 7,018[16]	9,073[2]	9,073[2]
1982	818[4]	941[8]	7,738[14] 6,952[4] 7,892[16]	10,126[2]	10,126[2]
1983	237[6]	353[9]	4,405[4] 4,737[16]	7,406[2]	7,406[2]
1984	280[6]	411[10]	3,631[15] 3,742[16] 4,360[4]	9,150[2]	9,150[2]
1985	543[6]	609[11]	4,766[16]	9,520[19]	9,391[19]
1986	814[6]	718[12]	4,409[16]	12,073[2]	11,546[2]
1987	917[7]	782[12]	5,632[16]	10,940[2] 12,807[5] 12,152[17]	10,668[2] 12,238[5] 11,758[17]
1988	1,089[7]	803[13]	6,483[16]	11,614[2] 11,055[5]	11,431[2] 10,616[5]
1989	1,307[7]	795[13]	8,951[16]	12,481[2] 12,700[5]	11,978[2] 12,257[5]

Table 3. The stable age distibution[a] (C_x) for a population of California sea lions with assumed survivorship schedules (l_x) and annual factor of increase of λ=1.000, λ=1.046, and λ=1.102.

Age		Females (C_x)				Males (C_x)		
(x)	l_x	λ=1.000	λ=1.046	λ=1.102	l_x	λ=1.000	λ=1.046	λ =1.102
1	1.000	0.158	0.206	0.260	1.000	0.199	0.244	0.295
2	0.702	0.111	0.138	0.166	0.643	0.128	0.150	0.172
3	0.534	0.084	0.101	0.114	0.468	0.093	0.104	0.114
4	0.431	0.068	0.078	0.084	0.371	0.074	0.079	0.082
5	0.365	0.058	0.063	0.064	0.314	0.063	0.064	0.063
6	0.320	0.051	0.053	0.051	0.277	0.055	0.054	0.050
7	0.289	0.046	0.045	0.042	0.252	0.050	0.047	0.042
8	0.266	0.042	0.040	0.035	0.234	0.047	0.042	0.035
9	0.248	0.039	0.036	0.030	0.220	0.044	0.037	0.030
10	0.235	0.037	0.032	0.026	0.207	0.041	0.034	0.026
11	0.223	0.035	0.029	0.022	0.195	0.039	0.030	0.022
12	0.213	0.034	0.027	0.019	0.183	0.036	0.027	0.019
13	0.204	0.032	0.024	0.017	0.167	0.033	0.024	0.015
14	0.195	0.031	0.022	0.014	0.148	0.029	0.020	0.012
15	0.185	0.029	0.020	0.012	0.125	0.025	0.016	0.009
16	0.174	0.028	0.018	0.011	0.097	0.019	0.012	0.007
17	0.161	0.025	0.016	0.009	0.067	0.013	0.008	0.004
18	0.145	0.023	0.014	0.007	0.038	0.008	0.004	0.002
19	0.127	0.020	0.012	0.006	0.017	0.003	0.002	
20	0.107	0.017	0.009	0.004				
21	0.084	0.013	0.007	0.003				
22	0.060	0.009	0.005	0.002				
23	0.038	0.006	0.003	0.001				
24	0.021	0.003	0.002					

[a]The stable age distribution, $C_x = \dfrac{\lambda^{-x} l_x}{\sum_{y=1}^{\infty} \lambda^{-y} l_y}$

Table 4. California sea lion population estimates from assumptions about male and female longevity (the 99th percentile of the age distribution) for: (a) 5 precent pre-census mortality; (b) 10 precent pre-census mortality; (c) 15 precent pre-census mortality; and (d) 20 precent pre-census mortality. The value for 15 precent pre-census mortality and 10.2% growth rate is the most likely (Bold value; refer to text).

	Pre-census pup mortality			
	5%	10%	15%	20%
Stock: United States				
Estimated births	28,039	29,374	30,709	32004
1990 Population estimate				
Growth rate:				
4.6%	125,464	131,442	137,412	143,211
10.2%	101,361	106,190	**111,016**	115,698
Stock: Baja California Pacific				
Estimated births	11,981	12,552	13,122	13,693
1990 Population estimate				
Growth rate:				
0%	67,986	71,232	**74,467**	77,702

Table 5. Estimates of California sea lions incidentally killed in California by commercial gillnet fisheries.

Fishing Year	Estimated Mortality	Standard Deviation	Reference
Apr 1983-Mar 1984	3,427	483.44	Hannan et al. (1988)
Apr 1984-Mar 1985	2,244	280.83	Hannan et al. (1988)
Apr 1985-Mar 1986	2,207	469.85	Hannan et al. (1988)
Apr 1986-Mar 1987	4,288	840.39	Hannan and Diamond (1989)
Apr 1988-Mar 1989	3,753	738.63	Perkins et al. (1992a)
Apr-Dec 1989	2,315	333.59	Perkins et al. (1992a)
Jan-Dec 1990	2,753	390.29	Perkins et al. (1992a)
Jan-Dec 1991	1,865	271.00	Perkins et al. (1992b)

Table 6. Live stranded California sea lions treated by Sea World of California, San Diego, California. Note: 1991 only includes January through July.

	Year					
Condition	1987	1988	1989	1990	1991	Total
Gillnet	0	0	3	2	4	9
Gunshot	0	3	0	1	1	5
Fish hooks	0	0	0	2	1	3
Total	0	3	3	5	6	17
Yearly treated total	56	62	69	90	154	431

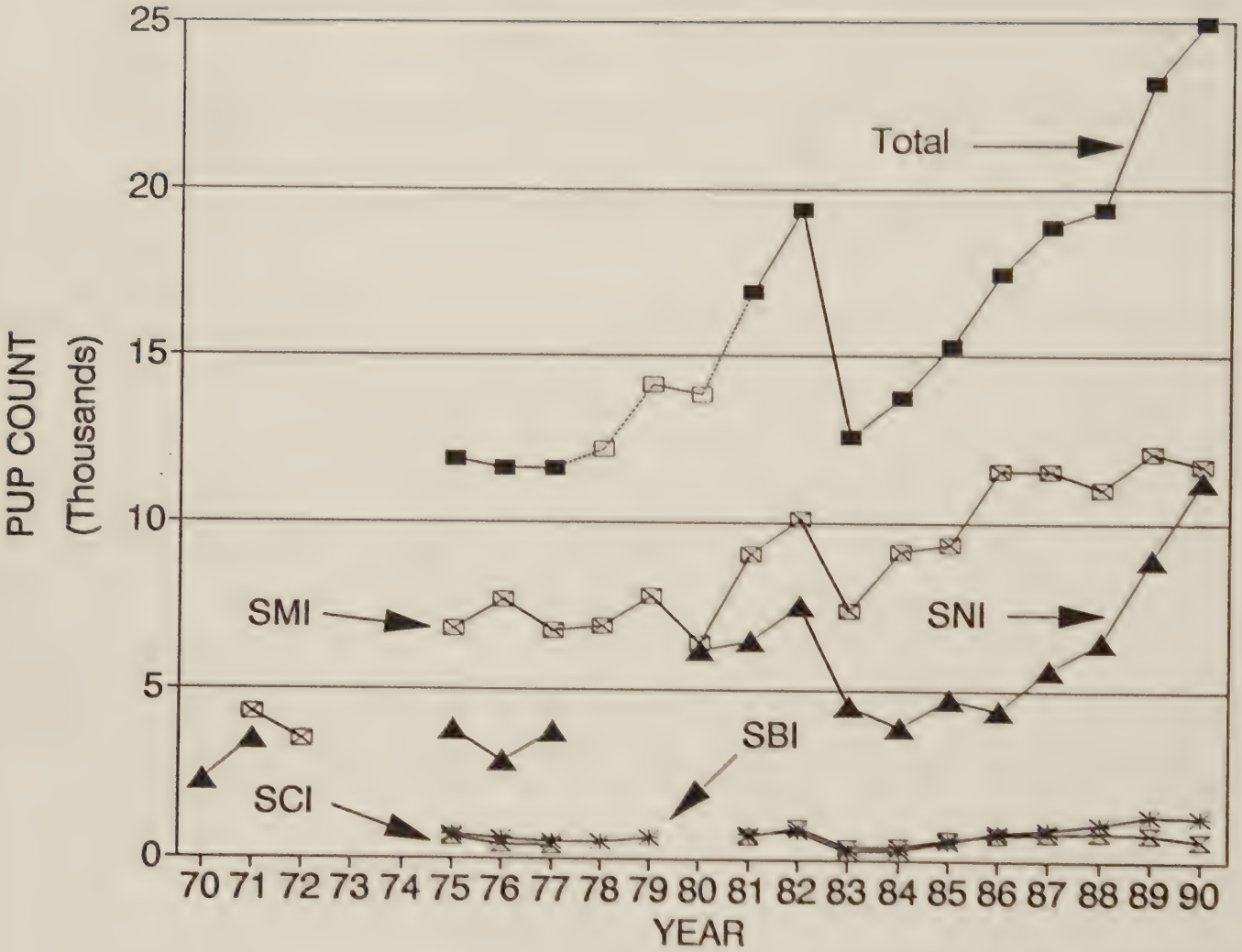

Figure 1. Counts of California sea lion pups at San Miguel Island (SMI; Index counts), San Nicolas Island (SNI), San Clemente Island (SCI), and Santa Barbara Island (SBI). The total count is shown for years in which counts were available for all four rookeries (solid squares). The total estimated count is shown for years in which counts were not available for all rookeries, but were estimated (open squares). Refer to Table 1 and to text for sources of data and citations. The average of multiple counts was used when more than one count was available.

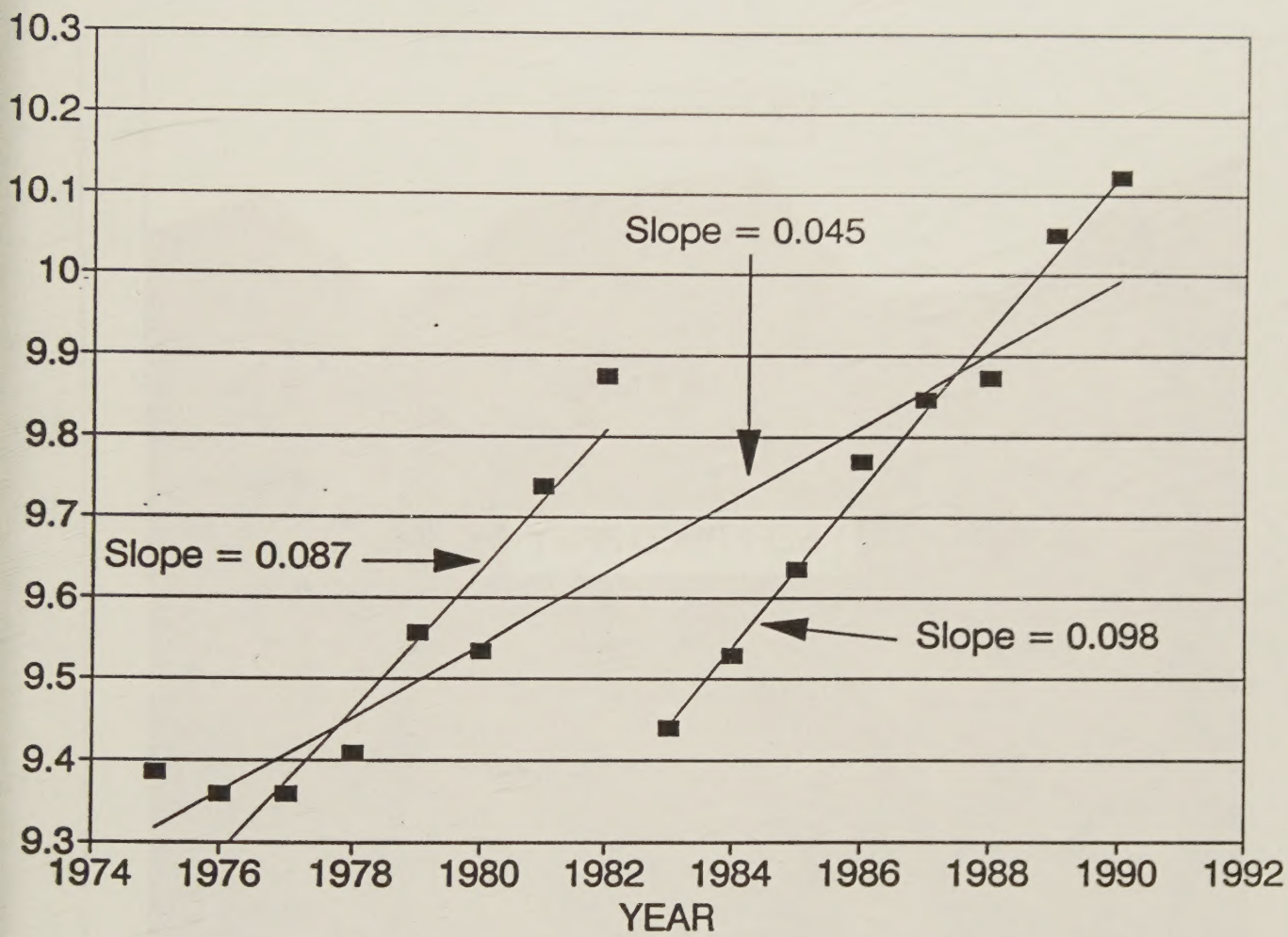

Figure 2. Natural logarithm of pup counts for the United States stock of California sea lions plotted against year, showing regression lines and slopes. Total counts for the U. S. stock are derived from counts made at San Miguel Island (using the SMI-Index), San Nicolas Island, Santa Barbara Island, and San Clemente Island.

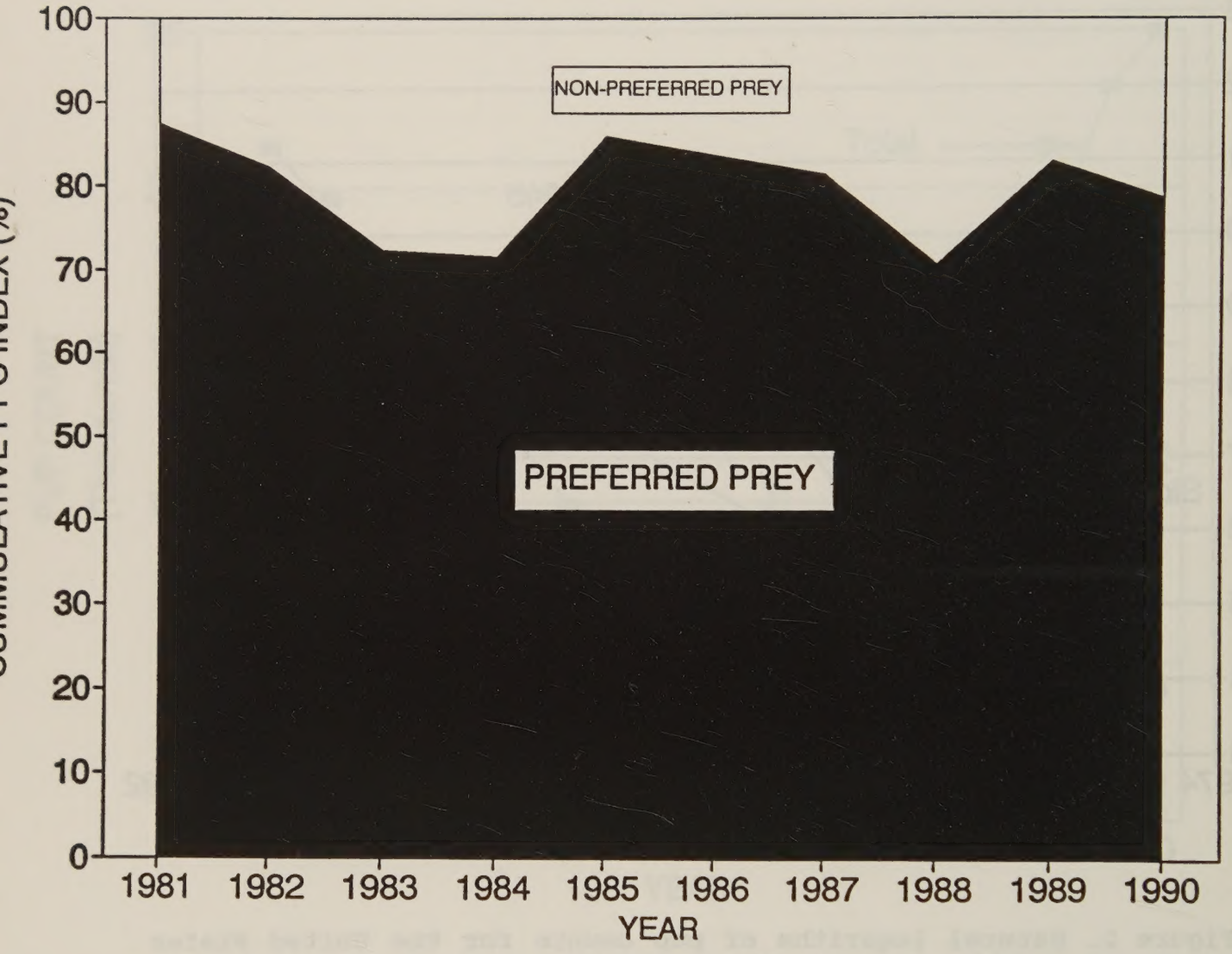

Figure 3. San Clemente Island percent prey composition index (SCI PPC-Index) of preferred prey taxa (Pacific whiting, northern anchovy, jack mackerel, Pacific mackerel, rockfish, and market squid) and of non-preferred taxa found in the diet of California sea lions at San Clemente Island, California. Prey not commonly found in the area (i.e. pelagic red crab) are excluded. Data obtained from scat samples collected year-round, except for 1981 which are only autumn and winter (Lowry unpubl. data).